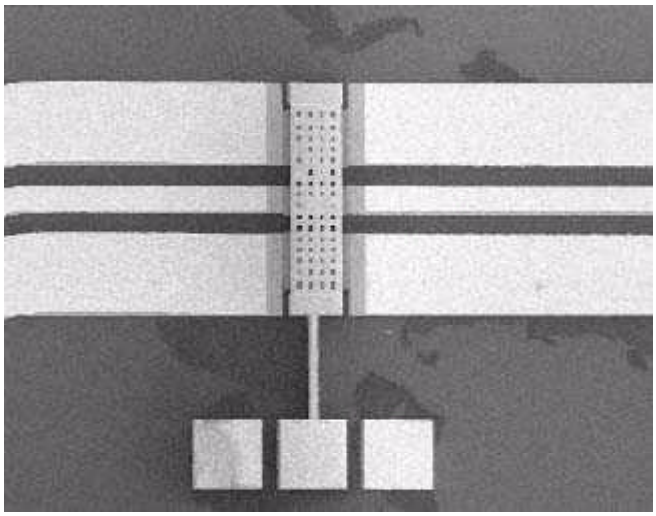
Low-Loss, High-Isolation Microwave Microelectromechanical Systems (MEMS) Switches Being Developed

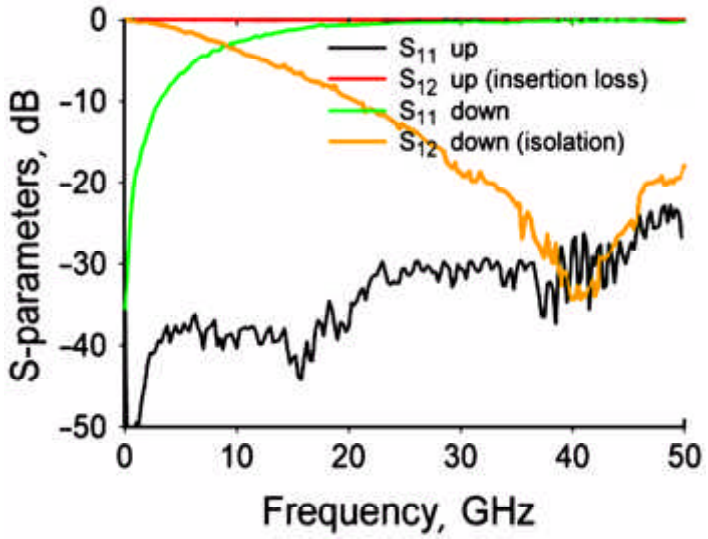
Switches, electrical components that either permit or prevent the flow of electricity, are the most important and widely used electrical devices in integrated circuits. In microwave systems, switches are required for switching between the transmitter and receiver; in communication systems, they are needed for phase shifters in phased-array antennas, for radar and communication systems, and for the new class of digital or software definable radios. Ideally, switches would be lossless devices that did not depend on the electrical signal's frequency or power, and they would not consume electrical power to change from OFF to ON or to maintain one of these two states. Reality is quite different, especially at microwave frequencies. Typical switches in microwave integrated circuits are pin diodes or gallium arsenide (GaAs) field-effect transistors that are nonlinear, with characteristics that depend on the power of the signal. In addition, they are frequency-dependent, lossy, and require electrical power to maintain a certain state. A new type of component has been developed that overcomes most of these technical difficulties. Microelectromechanical (MEMS) switches rely on mechanical movement as a response to an applied electrical force to either transmit or reflect electrical signal power.



Typical MEMS switch.

The NASA Glenn Research Center has been actively developing MEMS for microwave applications for over the last 5 years. Complete fabrication procedures have been developed so that the moving parts of the switch can be released with near 100-percent yield. Moreover, the switches fabricated at Glenn have demonstrated state-of-the-art performance. A typical MEMS switch is shown in this figure. The switch extends over the signal and ground lines of a finite ground coplanar waveguide, a commonly used microwave transmission line. In the state shown in this figure, the switch is in the UP state

and all the microwave power traveling along the transmission line proceeds unimpeded. When a potential difference is applied between the cantilever and the transmission line, the cantilever is pulled downward until it connects the signal line to the ground planes, creating a short circuit. In this state, all the microwave power is reflected. The following graph shows the measured performance of the switch, which has less than 0.1 dB of insertion loss and greater than 30dB of isolation. These switches consume negligible electrical power and are extremely linear. Additional research is required to address reliability and to increase the switching speed.



Measured characteristics of a MEMS switch in the UP and DOWN states.
Long description: Graph shows data for S_{11} up, S_{12} (insertion loss), S_{11} down, and S_{12} down (isolation).

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